

Integrating Watershed Management with Nonpoint Source Controls

Joanna S. Richey and Jonathan Frodge

King County, Water and Land Resources Division, Department of Natural Resource

Introduction

This paper describes the current and past efforts of four local jurisdictions, King County, and the cities of Bellevue, Issaquah and Redmond, to manage nonpoint source inputs of phosphorus to Lake Sammamish. Lake Sammamish is a large urban lake located five miles east of Seattle, Washington in one of the most rapidly growing parts of the central Puget Sound basin (Figure 1). The management program for the lake is watershed based and uses an adaptive management strategy. Adaptive management is a process to improve the management of natural resources by allowing scientists and managers to incorporate new scientific knowledge and technological advances into a management program incrementally. This strategy integrates monitoring results, the output of a computer model that estimates the potential phosphorus control and annual costs of different management options for changing land use, and shared decision making to determine the most cost-effective management actions for implementation on an annual basis.

Historical Background

Lake Sammamish is used extensively for recreation by the more than 2 million people in the greater Seattle area. It provides rearing and migratory habitat to several species of anadromous fish including chinook and coho salmon, several warm water fish, and many types of wildlife. Phosphorus is the limiting nutrient in the lake (Welch et al., 1980). Phosphorus enters the lake from a variety of nonpoint sources including soil erosion associated with land disturbance and clearing, construction sites, landscaped gardens and commercial properties, animal wastes, failing septic tanks, and roads. Seasonally recurring blooms of *Cyanobacteria* and green algae appear to be related to both the annual loading of phosphorus into the lake and the meteorological conditions during a given year. Increases in the annual phosphorus loading to the lake result in increased concentrations of algae in the lake and decreased lake transparency (Perkins et al., 1997).

The lake has a long history of management for phosphorus control that began 30 years ago with the diversion of wastewater effluent and industrial inputs in 1968. Although total phosphorus concentrations in the lake gradually decreased during the ten years following this diversion, increased development of the watershed during the last 20 years has resulted in total phosphorus concentrations that produce bloom conditions during most summers. Typically the algae blooms reduce the lake's aesthetic qualities and its desirability for contact recreation. Little information exists as to the affect of the blooms on populations of fish and other organisms in the lake.

Lake Sammamish, which drains a 98 square mile watershed, includes four different jurisdictions as well as significant public lands (Figure 1). The jurisdictions include parts of the cities of Bellevue and Redmond, all of the City of Issaquah, and part of King County.

A management plan was developed by the four jurisdictions in 1989 (Entranco, 1989). Many of the recommendations of the plan were implemented by the four jurisdictions as part of an inter-local agreement signed by the governments in 1991. However, full implementation of the plan depended upon the development and evaluation of improved phosphorus control facilities, as well as the development, funding, and implementation of multiple nonpoint source control regulations and techniques.

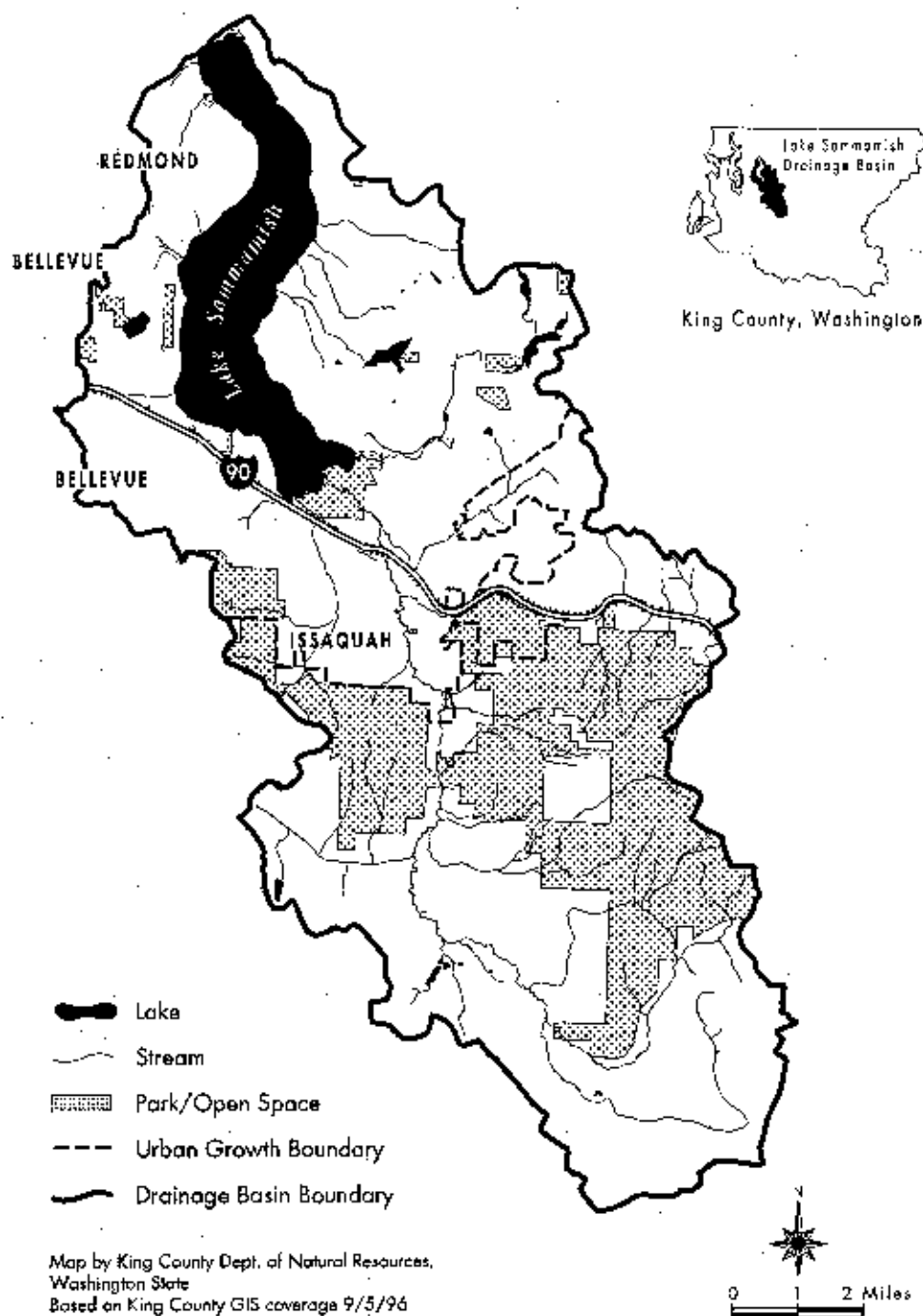


Figure 1. Lake Sammanish drainage basin.

While the development and evaluation of various phosphorus-control options took place, the lake's watershed continued to develop. Land-use changes in the watershed between 1985 and 1996 and predicted changes expected in the future based on current zoning are shown in Figure 2. In terms of phosphorus loading to the lake, the most significant change has been the conversion of forest land to single-family residential (SFR), and, to a lesser extent, multi-family (MFR) use and commercial use. In 1996, 77% of the annual phosphorus load was derived from SFR and MFR and commercial land use, although these land-use categories comprise only 46% of the watershed area (Entranco, 1996).

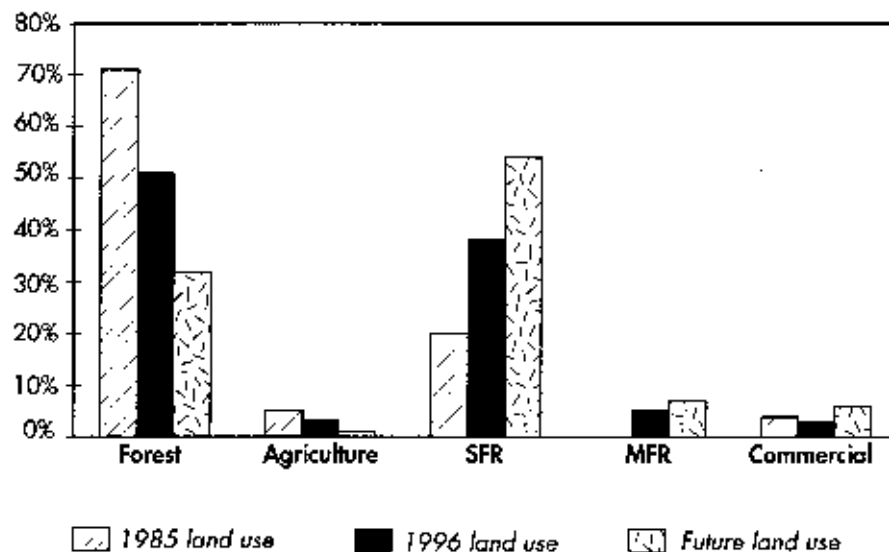


Figure 2. 1985, 1996, and future land use.

The 1996 Water Quality Management Plan

Based on a computer model, Perkins et al. (1997) predicted that the external phosphorus loading to the lake would increase above levels necessary to maintain the lake's water quality if the watershed continued to develop to its zoned capacity. In response, a citizen task force, Partners for a Clean Lake Sammamish (henceforth Partners), was appointed to review the water quality goals in the 1989 plan. Their charge was to identify cost-effective management options that would allow achievement of either the 1989 goals or new goals as defined by the community, and to identify costs and a financial plan for implementation.

The results of this effort showed that:

1. The community supported non-degradation water quality goals that maintained the current ecological health and public benefits of the lake;
2. Cost-effective management of nonpoint sources of phosphorus to the lake could likely be achieved by a multi-faceted program that uses new technology for phosphorus control facilities, an enhanced program for facilities maintenance, forest conservation, multiple programmatic and regulatory controls, and public acquisition of both upland and shoreline access parcels;
3. The costs of full implementation are large, including up to \$2 million/year in public costs and up to \$9 million/year in private costs for on-site water quality facilities, plus additional costs for acquisition of both shoreline access and upland public lands.

The management and financial recommendations developed by the citizen task force were submitted in July 1996 to an advisory forum of elected officials from the participating jurisdictions, the Sammamish Watershed Forum (Partners for a Clean Lake Sammamish, 1996). The Forum members supported the Plan's goals and strategy and recommended a combination of local and shared regional funding for its implementation. Specifically, the Forum recommended that the feasibility studies and public land acquisition should be paid for by shared regional funds while all other Plan recommendations should be funded by the four local governments, or by the private sector for on-site facilities for new development.

These recommendations and the analyses that supported them were summarized in the 1996 Water Quality Management Plan for Lake Sammamish (Entranco, 1996). The specific goal for the lake defined in the 1996 Plan is to protect the ecological health and public benefits of Lake Sammamish as described in the 1989 Lake Sammamish Water Quality Plan. The proposed measurements to confirm achievement of this goal are:

1. meters Secchi disk transparency (summer average)
2. µg/liter chlorophyll a (summer average)
3. µg/liter annual volume-weighted total phosphorus (These are the levels observed in summer 1995, and will be maintained through a management-tracking program for phosphorus inputs using the most cost effective measures available¹).

The 1996 Plan's recommendations for achieving these goals were identified using a predictive computer model, WAQCEM, the Watershed Quality Cost Effectiveness Model. WAQCEM compared the feasibility, costs, and effectiveness of different management alternatives to control future increases in phosphorus loading to the lake from changes in land use (Richey et al., in press). The citizen task force used the WAQCEM results to identify a multi-faceted management program that was feasible, in terms of using available technology, being consistent with state and local regulations and social acceptability; and being cost-effective. The overall intent of the combined recommendations was to maintain annual phosphorus loading at 1995–96 levels, as demonstrated by maintaining the non-degradation goal indicator levels. The on-going monitoring program measures in-lake concentrations of total phosphorus, chlorophyll *a*, and lake transparency. The effectiveness of the management program can be evaluated on the basis the goal indicator levels are met on an annual basis.

The 1996 Plan recommendations took advantage of new technology for phosphorus control facilities that had been developed and tested since 1989 (King County, 1996; 1998a) as well as regulatory and programmatic controls that had been partially implemented as part of the 1989 Plan. A significant part of the 1996 Plan depended upon supporting and expanding a program of forest conservation which had been mandated in a Basin Plan adopted for the Issaquah Creek sub-drainage basin in 1995 (King County, 1995, 1998b).

The Plan depends upon each different management option to achieve roughly the following percentage shares of eliminating the future predicted increase in phosphorus loading to the lake:

1. Twenty-five percent—a requirement that all new urban developments build on-site stormwater facilities that control 50% of the total phosphorus generated by the newly developed sites;
2. Twenty percent—nonpoint source control programs for best management practices to reduce the use and export of phosphorus and sediments from homes, gardens, businesses, pets, farms, forest, stormwater facilities and roadside ditches; and increased support for citizen stewardship and technical assistance programs for regulatory compliance in erosion control at construction sites, and regulations for steep slopes, riparian buffers and shorelines;
3. Forty percent—forest conservation program including support of re-vegetation, current use taxation programs, land conservation, best management practices, and enforcement of a 65% clearing limit for rural residential lots.

The remaining approximately 15% of the needed phosphorus control is expected to be attained through a combination of improved technology, increased support of nonpoint source control practices, and improved regulatory compliance during the years it will take to reach full development of the watershed. Depending upon the rate of urban development in the basin, the WAQCEM model predictions indicate that this additional level of phosphorus control will not be needed for fifteen or more years, assuming that the other controls are implemented now.

The Partners considered and rejected inclusion of two other phosphorus control strategies as part of the 1996 Plan. These were the development of regional stormwater treatment plants and the retrofitting of existing stormwater detention facilities for phosphorus control. The Partners felt that the difficulties of siting and permitting one or more regional stormwater treatment facilities combined with the lack of an existing financial mechanism for either public or private funding of such facilities offset their greater cost-effectiveness. Instead they recommended a further feasibility study. They rejected the option of retrofitting existing on-site facilities due to the high cost and limited amount of phosphorus control that would be achieved by this action.

Plan Implementation

The four jurisdictions supported the adaptive management strategy recommended by the citizen task force and the specific management recommendations. In particular, the adaptive management strategy is expected to help prevent delays in shifting the year-to-year management of the lake to respond to changes in the lake's water quality, land use in the watershed, technology, and the success or failure of different management options. As shown in Figure 3, the adaptive management strategy incorporates an iterative, annual evaluation of the effectiveness of different phosphorus control actions. Through in-lake monitoring, the strategy allows evaluation of the water quality goals for the lake based on quantitative indicators for chlorophyll a, total phosphorus, and lake transparency. The jurisdictions are developing a process which will institutionalize annual or less frequent adjustments and changes to the overall management of the lake's water quality based on the monitoring program results, changing technology, and land-use change as quantified using the WAQCEM (or derivative) models.

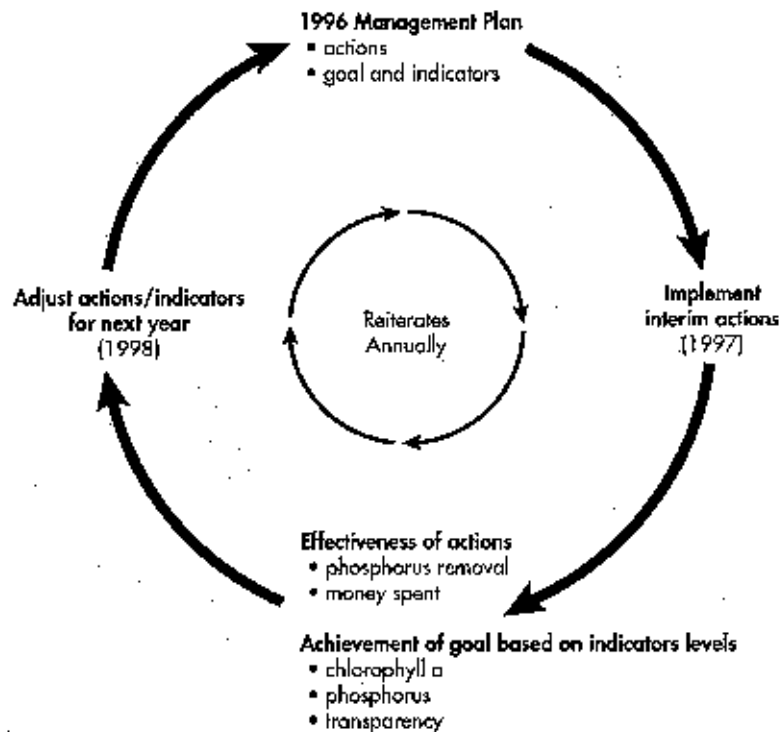


Figure 3. Lake Sammamish water-quality tracking program.
Note: cycle repeats for each incremental year.

Although there is no source of shared regional funds currently available in the area, the local governments funded implementation of parts of the plan during 1997 and 1998. Specifically, they supported the requirement for on-site water quality control facilities for new urban development throughout most of the watershed; the nonpoint source control and regulatory compliance support programs; and the forest conservation program. Parts of the enhanced maintenance program were funded, although some of the potential phosphorus control practices are being further evaluated prior to implementation. The local governments are also working to develop improved partnerships with state agencies in the watershed so that the various state agencies in the basin can focus on improving phosphorus control practices.

In accepting and funding the recommendations of the Plan, the jurisdictions recognize that there is a great deal of uncertainty associated with the effective implementation of nonpoint source control programs. Thus the assumptions built into the WAQCEM model are conservative and reflect low levels of participation on the part of citizens and businesses in most of the best management practices and typically half or less than half of the reported levels of phosphorus control for the different practices. The

low levels of participation were felt to be realistic given that, in the absence of financial or regulatory incentives, activities that require behavioral change on the part of thousands of individuals tend to occur very slowly.

The jurisdictions are supporting a wide range of outreach and public education programs as well as encouraging community groups and citizens to apply for stewardship grants for development of effective pilot programs. For example, citizens in one sub-drainage basin, Beaver Lake, received a grant to develop an outreach program and interpretive signs to encourage area residents to dispose of pet wastes properly so that the phosphorus they contain does not enter the surface waters.

Actual participation of citizens in residential best management practices is being evaluated through a series of public surveys that were started in the summer of 1997. It is hoped that the surveys will be extended to residents participating in the rural forest conservation program and the business programs. The monitoring of the actual effectiveness of the various controls will be dependent upon additional funding sources.

Monitoring of land-use change in the drainage basin is being evaluated through the updating of Geographic Information System (GIS) land-use data with development permit records. These updated GIS files will be used with the survey results in the WAQCEM model to determine, in conjunction with the in-lake water quality measures, if the various phosphorus controls should be modified or changed each year. It is expected that only minor changes will occur in the first few years since it takes time for citizens, businesses and public sector employees to change their day-to-day practices and for any changes to have an effect on phosphorus loading to the lake. For example, although total phosphorus concentrations in the lake during 1997 were slightly less than those observed in 1996 (Figure 4), this change is likely well within the year-to-year variability observed in the lake. It cannot yet be determined if there is any change in the phosphorus concentrations in the lake. The jurisdictions did not change management actions for 1998. It will take several years to determine whether or not there is a change in the overall water quality conditions in the lake.

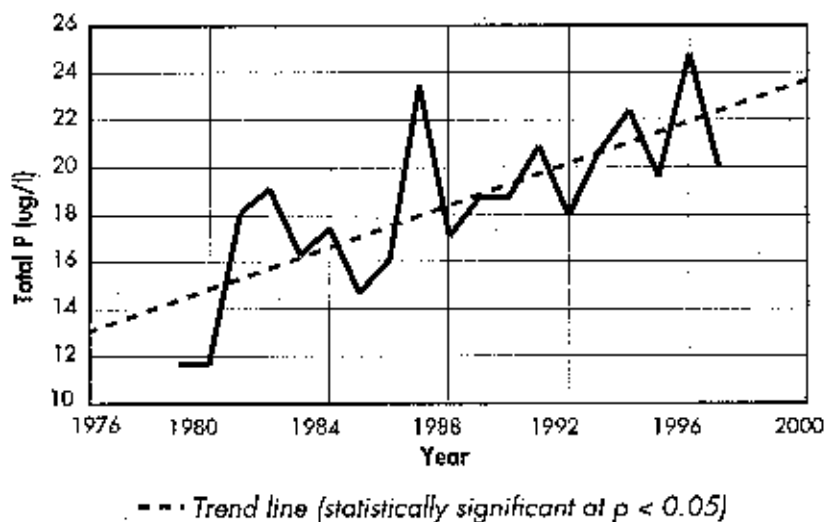


Figure 4. Total Phosphorus concentrations in Lake Sammamish 1979–1997.

Conclusions

The development and implementation of a watershed management plan for protecting the water quality in Lake Sammamish was, and is, dependent upon the active involvement of the citizens, businesses and governments that share the drainage basin. Due to the nonpoint nature of the pollutant of concern, phosphorus, there is no single solution that can prevent degradation of the lake's water

quality. Instead, a wide range of structural and non-structural controls is needed. In recognition of the fact that new technology and science may change the lake's management needs, the citizens and governments agreed to an adaptive management strategy. This strategy incorporates explicit review of the effectiveness of different management actions and land-use changes in the drainage basin. It allows for the introduction of new strategies, practices, or technologies into the management plan as needed.

The Plan recognizes that no one party is responsible for controlling the sources of phosphorus in the drainage basin. Rather, all activities that have the potential to generate phosphorus have been targeted. Structural controls, such as on-site water quality treatment facilities are being used for new development only since retrofitting of old urban development proved to be very expensive and unlikely to result in significant removal of phosphorus. The majority of phosphorus control is expected to be achieved through the conservation of forest and best management practices in the rural and forest production lands and through best management practices in the urban lands. Public funds support these practices through education and stewardship programs, technical assistance and compliance support programs and small grants.

The success of the Plan will be evaluated through time as part of the on-going adaptive management strategy and through the in-lake monitoring program.

Acknowledgments

Funding for the work described in this paper was provided by King County and the cities of Bellevue, Issaquah and Redmond. Additional support was provided by the Washington Department of Ecology. The authors would also like to thank the Lake Sammamish Technical and Management Committees, the Partners for a Clean Lake Sammamish, Dale Anderson, Brian Taylor, and Beth Schmoyer for their contributions to this work; and Laurel Preston, Wendy Gable and Jeff Richey for their assistance in manuscript preparation.

References

- Entranco Engineers, Inc. 1989. Lake Sammamish Water Quality Management Project, Technical Report to Washington Department of Ecology, Metro, King County, Redmond, Issaquah and Bellevue, October 1989.
- Entranco Engineers, Inc. 1996. Lake Sammamish Water Quality Management Plan, Prepared for King County, Bellevue, Issaquah and Redmond, December 1996.
- King County. 1995. Issaquah Creek Basin and Nonpoint Action Plan, King County Surface Water Management, King County, WA.
- King County. 1996. Surface Water Design Manual, King County Water and Land Resources Division, King County WA, February 1996 Draft.
- King County. 1998a. Lake Sammamish Water Quality Management Project, March 1998 Report, prepared for the Washington Department of Ecology by King County, Redmond, Issaquah and Bellevue, March 1998.
- King County. 1998b. Forest Conservation Program in the Issaquah Creek Basin/Lake Sammamish Drainage Basin; Status and Findings: An Issue Paper, King County Water and Land Resources Division, February 1998.
- Partners for a Clean Lake Sammamish. 1996. Final Report and Recommendations, July 1996, King County, WA.
- Perkins, W.W., E.B. Welch, J. Frodge, and T. Hubbard. 1997. A Zero Degree of Freedom Total Phosphorus Model: 2: Application to Lake Sammamish, Washington, *Journal of Lake and Reservoir Management* 13(2): 131–141.
- Richey, J. S., D. Anderson, and B. Taylor. in press. A Cost-Effectiveness Model for Evaluating Management Options for Phosphorus Loading to Lakes, Conference Proceedings, Watershed Management Theory and Practice, Water Environment Federation, Denver, CO, May 1998.
- Welch, E.B., C.A. Rock, R.C. Howe, and M.A. Perkins. 1980. Lake Sammamish Response to Wastewater Diversion and Increasing Urban Runoff. *Water Resources* 14:821–828.

¹ The management-tracking program will use an adaptive management strategy that allows incremental changes in management in response to experience, scientific finding and new technology.